

## CLAIMS

What is claimed is:

5           1.     A method of determining the sensing a specified object  
with respect to a reference surface, said method comprising the steps  
of:

          a) providing an array of near-field antenna elements in the form  
of electrode or coil structures, heretofore termed “sensing elements”;

10           b) generating electromagnetic signals via DC or AC coupling to  
sensing elements having one or more characteristic frequencies of  
oscillation;

          c) providing a means for measuring said characteristic  
frequencies .

15           c) coupling the generated electromagnetic field to said object  
capacitively and/or inductively via one or more sensing elements; and

          d) measuring changes in said characteristic frequencies that are  
caused by said object;

2. The method of Claim 2, wherein the measured changes in characteristic frequencies are used to determine the presence, identity, position, or orientation of said object;

3. The method of Claim 2, wherein the measured changes in  
5 characteristic frequencies are used to determine the presence of said object;

4. The method of Claim 2, wherein the measured changes in characteristic frequencies are used to determine the identity of said object having known material properties;

10 5. The method of Claim 2, wherein the measured changes in characteristic frequencies are used to determine the position of said object;

6. The method of Claim 2, wherein the measured changes in characteristic frequencies are used to determine the 2-dimensional  
15 orientation of said object in the plane of the sensing surface;

7. The method in Claim 2, wherein step d) is carried out with the aid of a frequency counter.

8. The method in Claim 2, wherein the coupling of said electromagnetic radiation to said object is capacitive in nature.

9. The method in Claim 2, wherein the coupling of said electromagnetic radiation to said object is inductive in nature.

10. The method in Claim 8, further comprising the steps of:

providing for each antenna element, an oscillator coupled thereto;

providing a multiplexer coupled at its outputs to each oscillator;

and

selecting via said multiplexer, an oscillator-antenna combination for transmitting said electromagnetic radiation.

11. The method in Claim 9, further comprising the steps of:

providing for each antenna element, an oscillator coupled thereto;

providing a multiplexer coupled at its outputs to each oscillator;

and

selecting via said multiplexer, an oscillator-antenna combination for transmitting said electromagnetic radiation.

12. The method in Claim 8, further comprising the steps of:

providing an oscillator for carrying out step b);

providing a multiplexer coupled at its input to said oscillator,

and coupled at its outputs to said antenna elements; and

selecting via said multiplexer, a antenna element for transmitting said electromagnetic radiation.

13. The method in Claim 9, further comprising the steps of:

providing an oscillator for carrying out step b);

5 providing a multiplexer coupled at its input to said oscillator, and coupled at its outputs to said antenna elements; and

selecting via said multiplexer, a antenna element for transmitting said electromagnetic radiation.

14. The method in Claim 8, further comprising the steps of:

10 providing at least a masking element for masking selected antenna elements; and

selectively masking the antenna elements so that the only the unmasked elements are responsive to electromagnetic coupling to the object being sensed.

15 15. The method in Claim 9, further comprising the steps of:

providing at least one masking element for the purpose of masking selected electrodes; and

selectively masking electrodes so that the only the unmasked electrodes are responsive to electromagnetic radiation received from  
20 said object.

16. The method in Claim 2, further comprising the steps of:  
modulating transmitted electromagnetic radiation in a manner  
which can be used to convey information to one or more external  
electronic devices receptive to said electromagnetic radiation.

5 17. The method in Claim 8, further comprising the steps of:  
modulating transmitted electromagnetic radiation in a manner  
which can be used to convey information to one or more external  
electronic devices.

10 18. The method in Claim 9, further comprising the steps of:  
modulating transmitted electromagnetic radiation in a manner  
which can be used to convey information to one or more external  
electronic devices.

15 19. The method in Claim 2, further comprising the steps of:  
providing for said object, at least one or more electromagnetic  
markers comprised of material with electromagnetic properties  
(electrical conductivity,  $\sigma$ , magnetic permeability,  $\mu$ , and dielectric  
constant,  $\epsilon$ ) appreciably different from that of the object;

20 wherein the electromagnetic material properties of the markers  
produce detectable frequency shifts in the sensing array, and the  
spatial pattern of the markers on or in the object enables identification

of the object and enhances the derivation of position and orientation information about said object.

20. The method in Claim 8, further comprising the steps of:

providing for said object, at least one or more electromagnetic  
5 markers comprised of material with electromagnetic properties  
(electrical conductivity,  $\sigma$ , magnetic permeability,  $\mu$ , and dielectric  
constant,  $\epsilon$ ) appreciably different from that of the object;

wherein the electromagnetic material properties of the markers  
produce detectable frequency shifts in the sensing array, and the  
10 spatial pattern of the markers on or in the object enables identification  
of the object and enhances the derivation of position and orientation  
information about said object.

21. The method in Claim 9, further comprising the steps of:

providing for said object, at least one or more electromagnetic  
15 markers comprised of material with electromagnetic properties  
(electrical conductivity,  $\sigma$ , magnetic permeability,  $\mu$ , and dielectric  
constant,  $\epsilon$ ) appreciably different from that of the object;

wherein the electromagnetic material properties of the markers  
produce detectable frequency shifts in the sensing array, and the  
20 spatial pattern of the markers on or in the object enables identification

of the object and enhances the derivation of position and orientation information about said object.

22. The method in Claim 2, further comprising the steps of:

providing for said object, at least one or more electromagnetic  
5 markers comprised of electrically conductive elements to be placed thereon;

wherein the electromagnetic material properties of the markers produce detectable frequency shifts in the sensing array, and the spatial pattern of the markers on or in the object enables identification  
10 of the object and enhances the derivation of position and orientation information about said object.

23. The method in Claim 8, further comprising the steps of:

providing for said object, at least one or more electromagnetic markers comprised of electrically conductive elements to be placed  
15 thereon;

wherein the electromagnetic material properties of the markers produce detectable frequency shifts in the sensing array, and the spatial pattern of the markers on or in the object enables identification of the object and enhances the derivation of position and orientation  
20 information about said object.

24. The method in Claim 9, further comprising the steps of:

providing for said object, at least one or more electromagnetic markers comprised of electrically conductive elements to be placed thereon;

5 wherein the electromagnetic material properties of the markers produce detectable frequency shifts in the sensing array, and the spatial pattern of the markers on or in the object enables identification of the object and enhances the derivation of position and orientation information about said object.

10 25. The method in Claim 2, further comprising the steps of:

providing for said object, at least one or more electromagnetic markers comprised of magnetically permeable elements (defined as having  $\mu \gg 1$ ) to be placed thereon;

15 wherein the electromagnetic material properties of the markers produce detectable frequency shifts in the sensing array, and the spatial pattern of the markers on or in the object enables identification of the object and enhances the derivation of position and orientation information about said object.

26. The method in Claim 8, further comprising the steps of:



providing for said object, at least one or more electromagnetic markers comprised of magnetically permeable elements (defined as having  $\mu \gg 1$ ) to be placed thereon;

wherein the electromagnetic material properties of the markers  
5 produce detectable frequency shifts in the sensing array, and the spatial pattern of the markers on or in the object enables identification of the object and enhances the derivation of position and orientation information about said object.

27. The method in Claim 9, further comprising the steps of:

10 providing for said object, at least one or more electromagnetic markers comprised of magnetically permeable elements (defined as having  $\mu \gg 1$ ) to be placed thereon;

wherein the electromagnetic material properties of the markers produce detectable frequency shifts in the sensing array, and the  
15 spatial pattern of the markers on or in the object enables identification of the object and enhances the derivation of position and orientation information about said object.

28. The method in Claim 2, further comprising the steps of:

providing for said object, at least one or more electromagnetic markers comprised of material with a dielectric constant ( $\epsilon$ ) appreciably greater than the dielectric constant of the object;

wherein the electromagnetic material properties of the markers  
5 produce detectable frequency shifts in the sensing array, and the spatial pattern of the markers on or in the object enables identification of the object and enhances the derivation of position and orientation information about said object.

29. The method in Claim 8, further comprising the steps of:

10 providing for said object, at least one or more electromagnetic markers comprised of material with a dielectric constant ( $\epsilon$ ) appreciably greater than the dielectric constant of the object;

wherein the electromagnetic material properties of the markers  
15 produce detectable frequency shifts in the sensing array, and the spatial pattern of the markers on or in the object enables identification of the object and enhances the derivation of position and orientation information about said object.

30. The method in Claim 9, further comprising the steps of:

providing for said object, at least one or more electromagnetic markers comprised of material with a dielectric constant ( $\epsilon$ ) appreciably greater than the dielectric constant of the object;

wherein the electromagnetic material properties of the markers  
5 produce detectable frequency shifts in the sensing array, and the spatial pattern of the markers on or in the object enables identification of the object and enhances the derivation of position and orientation information about said object.

31. An apparatus for determining the position and orientation  
10 of a specified object with respect to a reference surface, said apparatus comprising:

a set of near-field antenna elements in the form of electrodes or coils;

a sensing array comprised of sensing elements;

15 at least one controlled oscillator that is DC or AC coupled to said sensing elements having one or more characteristic frequencies of oscillation; and

measuring circuitry coupled to said sensing array adapted to measure changes in one or more said characteristic frequencies;

wherein said electromagnetic radiation is coupled to said object,  
and the changes in one or more said characteristic frequencies is used  
to derive position or orientation of said object.

32. The apparatus in Claim 31, wherein said measuring  
5 circuitry comprises a frequency counter.

33. The apparatus in Claim 31, wherein the coupling of said  
electromagnetic radiation to said object is capacitive in nature.

34. The apparatus in Claim 31, wherein the coupling of said  
electromagnetic radiation to said object is inductive in nature.

10 35. The apparatus in Claim 33, further comprising:  
a controlled oscillator for each antenna element; and  
a multiplexer coupled at its outputs to each oscillator;  
wherein said multiplexer is adapted to select an oscillator-  
antenna combination for transmitting said electromagnetic radiation.

15 36. The apparatus in Claim 34, further comprising:  
a controlled oscillator for each antenna element; and  
a multiplexer coupled at its outputs to each oscillator;  
wherein said multiplexer is adapted to select an oscillator-  
antenna combination for transmitting said electromagnetic radiation.

20 37. The apparatus in Claim 33, further comprising:

a multiplexer coupled at its input to said oscillator, and coupled at its outputs to said antenna elements;

wherein said multiplexer is adapted to select a antenna element for transmitting said electromagnetic radiation.

5        38.    The apparatus in Claim 34, further comprising:

a multiplexer coupled at its input to said oscillator, and coupled at its outputs to said antenna elements;

wherein said multiplexer is adapted to select a antenna element for transmitting said electromagnetic radiation.

10       39.    The apparatus in Claim 33, further comprising:

at least a masking element adapted to mask selected electrodes;

wherein electrodes are selectively masked so that only the unmasked electrodes are responsive to electromagnetic radiation received from said object.

15       40.    The apparatus in Claim 34, further comprising:

at least a masking element adapted to mask selected electrodes;

wherein electrodes are selectively masked so that only the unmasked electrodes are responsive to electromagnetic coupling to an object being sensed.

20       41.    The apparatus in Claim 31, further comprising:

masking elements for modulating transmitted electromagnetic radiation in a manner which can be used to convey information to one or more external electronic devices receptive to said electromagnetic radiation.

5           42.   The apparatus in Claim 33, further comprising:

masking elements for modulating transmitted electromagnetic radiation in a manner which can be used to convey information to one or more external electronic devices receptive to said electromagnetic radiation.

10           43.   The apparatus in Claim 34, further comprising:

masking elements for modulating transmitted electromagnetic radiation in a manner which can be used to convey information to one or more external electronic devices receptive to said electromagnetic radiation.

15           44.   The apparatus in Claim 31, further comprising:

for said object, at least one or more electromagnetic markers comprised of electrically conductive elements to be placed thereon;

wherein the electromagnetic material properties of the markers produce detectable frequency shifts in the sensing array, and the  
20   spatial pattern of the markers on or in the object enables identification

of the object and enhances the derivation of position and orientation information about said object.

45. The apparatus in Claim 33, further comprising:

for said object, at least one or more electromagnetic markers  
5 comprised of electrically conductive elements to be placed thereon;

wherein the electromagnetic material properties of the markers produce detectable frequency shifts in the sensing array, and the spatial pattern of the markers on or in the object enables identification of the object and enhances the derivation of position and orientation  
10 information about said object.

46. The apparatus in Claim 34, further comprising:

for said object, at least one or more electromagnetic markers comprised of electrically conductive elements to be placed thereon;

wherein the electromagnetic material properties of the markers  
15 produce detectable frequency shifts in the sensing array, and the spatial pattern of the markers on or in the object enables identification of the object and enhances the derivation of position and orientation information about said object.

47. The apparatus in Claim 31, further comprising:

for said object, at least one or more electromagnetic markers comprised of material with electromagnetic properties (electrical conductivity,  $\sigma$ , magnetic permeability,  $\mu$ , and dielectric constant,  $\epsilon$ ) appreciably different from that of the object;

5            wherein the electromagnetic material properties of the markers produce detectable frequency shifts in the sensing array, and the spatial pattern of the markers on or in the object enables identification of the object and enhances the derivation of position and orientation information about said object.

10           48.    The apparatus in Claim 33, further comprising:

for said object, at least one or more electromagnetic markers comprised of material with electromagnetic properties (electrical conductivity,  $\sigma$ , magnetic permeability,  $\mu$ , and dielectric constant,  $\epsilon$ ) appreciably different from that of the object;

15           wherein the electromagnetic material properties of the markers produce detectable frequency shifts in the sensing array, and the spatial pattern of the markers on or in the object enables identification of the object and enhances the derivation of position and orientation information about said object.

20           49.    The apparatus in Claim 34, further comprising:



for said object, at least one or more electromagnetic markers comprised of material with electromagnetic properties (electrical conductivity,  $\sigma$ , magnetic permeability,  $\mu$ , and dielectric constant,  $\epsilon$ ) appreciably different from that of the object;

5        wherein the electromagnetic material properties of the markers produce detectable frequency shifts in the sensing array, and the spatial pattern of the markers on or in the object enables identification of the object and enhances the derivation of position and orientation information about said object.

10        50.    The apparatus in Claim 31, further comprising:

for said object, at least one or more electromagnetic markers comprised of magnetically permeable elements (defined as having  $\mu \gg 1$ ) to be placed thereon;

15        wherein the electromagnetic material properties of the markers produce detectable frequency shifts in the sensing array, and the spatial pattern of the markers on or in the object enables identification of the object and enhances the derivation of position and orientation information about said object.

51.    The apparatus in Claim 33, further comprising:

for said object, at least one or more electromagnetic markers comprised of magnetically permeable elements (defined as having  $\mu \gg 1$ ) to be placed thereon;

wherein the electromagnetic material properties of the markers  
5 produce detectable frequency shifts in the sensing array, and the spatial pattern of the markers on or in the object enables identification of the object and enhances the derivation of position and orientation information about said object.

52. The apparatus in Claim 34, further comprising:

10 for said object, at least one or more electromagnetic markers comprised of magnetically permeable elements (defined as having  $\mu \gg 1$ ) to be placed thereon;

wherein the electromagnetic material properties of the markers produce detectable frequency shifts in the sensing array, and the  
15 spatial pattern of the markers on or in the object enables identification of the object and enhances the derivation of position and orientation information about said object.

53. The apparatus in Claim 31, further comprising:

for said object, at least one or more electromagnetic markers  
comprised of material with a dielectric constant ( $\epsilon$ ) appreciably  
greater than the dielectric constant of the object;

wherein the electromagnetic material properties of the markers  
5 produce detectable frequency shifts in the sensing array, and the  
spatial pattern of the markers on or in the object enables identification  
of the object and enhances the derivation of position and orientation  
information about said object.

54. The apparatus in Claim 33, further comprising:

10 for said object, at least one or more electromagnetic markers  
comprised of material with a dielectric constant ( $\epsilon$ ) appreciably  
greater than the dielectric constant of the object;

wherein the electromagnetic material properties of the markers  
produce detectable frequency shifts in the sensing array, and the  
15 spatial pattern of the markers on or in the object enables identification  
of the object and enhances the derivation of position and orientation  
information about said object.

55. The apparatus in Claim 34, further comprising:

for said object, at least one or more electromagnetic markers  
comprised of material with a dielectric constant ( $\epsilon$ ) appreciably  
greater than the dielectric constant of the object;

wherein the electromagnetic material properties of the markers  
5 produce detectable frequency shifts in the sensing array, and the  
spatial pattern of the markers on or in the object enables identification  
of the object and enhances the derivation of position and orientation  
information about said object.

10

15

20